Amendments to Claims

This listing of claims will replace all prior versions, and listings. of the claims in the application.

Listing of Claims:

Claim 1. (Original) A method for generating a discrete multitone signal comprising:

modulating N carriers, corresponding to respective subchannels, in each sample period of the signal by performing an inverse discrete Fourier transform of N modulation symbols each of which symbols represents a signal point in a QAM constellation for a respective subchannel, said

QAM constellation comprising a basic constellation of $M \geq 2^m$ signal points where m is the number of data bits to be communicated over the subchannel in a said sample period;

defining, for each of $N_c \leq N$ of said subchannels, an expanded QAM constellation comprising pM signal points including said basic constellation of points, where p is an integer greater than 1;

defining, in each said expanded constellation, p-1 equivalent signal points for each signal point of the basic constellation, where each of the p-1 equivalent points is selected from redundant points in the opposite quadrant of the constellation to the corresponding point of the basic constellation; and,

generating the discrete multitone signal in a said sample period by selecting, for each of said N_c subchannels, the modulation symbol representing either a basic constellation point or a corresponding equivalent point such that the peak value of the signal does not exceed a predetermined threshold.

Claim 2. (Original) A method according to claim 1 wherein, when the modulation symbol representing a said equivalent point is selected for a subchannel, the method includes performing said inverse discrete Fourier

transform using the modulation symbol representing said equivalent point to generate the discrete multitone signal.

Claim 3. (Currently Amended) A method according to claim 1 wherein said expanded QAM constellations and said equivalent signal points are defined implicitly by a prestored set of correction values, each correction value representing ~~the~~ a perturbation to be applied to a discrete multitone signal generated by performing said inverse discrete Fourier transform using a modulation symbol representing a basic constellation point to obtain the discrete multitone signal generated by performing said inverse discrete Fourier transform using the modulation symbol representing a corresponding equivalent signal point, and wherein, when the modulation symbol representing a said equivalent point is selected for a subchannel, the method includes performing said inverse discrete Fourier transform using the modulation symbol representing the corresponding basic constellation point, and applying to ~~the~~ a resulting signal the correction value corresponding to said equivalent point to generate the discrete multitone signal.

Claim 4. (Original) A method according to claim 1 wherein $p = 2$.

Claim 5. (Original) A method according to claim 1 wherein the discrete multitone signal is generated in a said sample period by:

(a) performing said inverse discrete Fourier transform using modulation symbols representing basic constellation points for said N subchannels;

(b) determining whether the peak value of the resulting signal exceeds said threshold, and if so selecting, for at least one of said N_c subchannels, the modulation symbol representing a corresponding equivalent point; and

(c) repeating step (b) until the peak value of the signal does not exceed said threshold.

Claim 6. (Original) A method according to claim 5 wherein, in successive iterations of step (b), different permutations of q modulation symbols representing equivalent signal points are selected, where q = 1 in a first pass and q = q + 1 in each subsequent pass.

Claim 7. (Original) A method according to claim 1 wherein the discrete multitone signal comprises said N subchannels and one or more further subchannels.

Claim 8. (Currently Amended) A method according to claim 7 wherein said further subchannels comprise respective subchannels at dc and ~~the~~ a Nyquist frequency which are not modulated.

Claim 9. (Original) A method according to claim 1 wherein $M = 2^m$.

Claim 10. (Currently Amended) A method according to claim 1 wherein a said expanded constellation is selected from possible constellations of pM signal points as the constellation providing ~~the~~ a lowest average transmit power.

Claim 11. (Original) Apparatus for generating a discrete multitone signal, the apparatus comprising:

a modulator for modulating N carriers, corresponding to respective subchannels, in each sample period of the signal by performing an inverse discrete Fourier transform of N modulation symbols, each of which symbols represents a signal point in a QAM constellation for a respective subchannel, said QAM constellation comprising a basic constellation of $M \geq 2m$ signal points where m is the number of data bits to be communicated over the subchannel in a said sample period;

means defining, for each of $Nc \leq N$ of said subchannels, an expanded QAM constellation comprising pM signal points including said basic constellation

of points, where p is an integer greater than 1, and further defining, in each said expanded constellation, p-1 equivalent signal points for each signal point of the basic constellation, where each of the p-1 equivalent points is selected from redundant points in the opposite quadrant of the constellation to the corresponding point of the basic constellation; and

control logic for selecting, for each of the N_c subchannels, the modulation symbol representing either a basic constellation point or a corresponding equivalent point for generation of the discrete multitone signal in a said sample period such that the peak value of the signal does not exceed a predetermined threshold value.

Claim 12. (Original) Apparatus according to claim 11 wherein said means defining said expanded constellations and said equivalent points comprises a QAM encoder, and wherein the control logic is configured to control the modulator such that, when the modulation symbol representing a said equivalent point is selected for a subchannel, the modulator performs said inverse discrete Fourier transform using the modulation symbol representing said equivalent point to generate the discrete multitone signal.

Claim 13. (Currently Amended) Apparatus according to claim 11 wherein:

said means defining said expanded constellations and equivalent signal points comprises a memory storing a set of correction values which define said expanded constellations and said equivalent signal points implicitly, each correction value representing ~~the~~ a perturbation to be applied to a discrete multitone signal generated by performing said inverse discrete Fourier transform using a modulation symbol representing a basic constellation point to obtain the discrete multitone signal generated by performing said inverse discrete Fourier transform using the modulation symbol representing a corresponding equivalent signal point;

the modulator is configured to perform said inverse discrete Fourier transform using modulation symbols representing basic constellation points for said N subchannels;

and wherein, when the modulation symbol representing [[a]] said equivalent point is selected for a subchannel, the control logic is configured to apply the correction value corresponding to said equivalent point to the signal produced by the modulator to generate the discrete multitone signal.

Claim 14. (Original) Apparatus according to claim 11 wherein p = 2.

Claim 15. (Currently Amended) Apparatus according to claim 11 wherein:

the modulator is configured to perform said inverse discrete Fourier transform using modulation symbols representing basic constellation points for said N subchannels; and the control logic is configured to (a) determine whether the peak value of ~~the~~ a resulting signal exceeds said threshold, and if so to select, for at least one of said N_c subchannels, the modulation symbol representing a corresponding equivalent point, and (b) to repeat step (a) until the peak value of the signal does not exceed said threshold.

Claim 16. (Original) Apparatus according to claim 15 wherein the control logic is configured to select different 25 permutations of q modulation symbols representing equivalent signal points in successive iterations of step (a), where q = 1 in a first pass and q = q+ 1 in each subsequent pass.

Claim 17. (Original) Apparatus according to claim 11 wherein $M = 2^m$.

Claim 18. (Currently Amended) A communication system comprising:
a transmitter for transmitting a discrete multitone signal, the transmitter comprising:

a modulator for modulating N carriers, corresponding to respective subchannels, in each sample period of the signal by performing an inverse discrete Fourier transform of N modulation symbols, each of which symbols represents a signal point in a QAM constellation for a respective subchannel, said QAM constellation comprising a basic constellation of $M \geq 2^m$ signal points where m is the number of data bits to be communicated over the subchannel in a said sample period;

means defining, for each of $N^c \leq N$ of said subchannels, an expanded QAM constellation comprising pM signal points including said basic constellation of points, where p is an integer greater than 1, and further defining, in each said expanded constellation, p-1 equivalent signal points for each signal point of the basic constellation, where each of the p-1 equivalent points is selected from redundant points in the opposite quadrant of the constellation to the corresponding point of the basic constellation; and control logic for selecting, for each of the N_c subchannels, the modulation symbol representing either a basic constellation point or a corresponding equivalent point for generation of the discrete multitone signal for transmission in [[a]] said sample period such that the peak value of the signal does not exceed a predetermined threshold value;
and a receiver for receiving and demodulating such a discrete multitone signal to generate the data represented thereby.